

1x & 4x branch Distortion Problem

& solution

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I) Problem:

If I choose to select samples from 1x branch while either [4x branch was on (and it is allowed to saturate)] or [if I switch off 4x branch before saturation, but allow it to be on for linear range of 4x], ~~THD~~ & SFDR = 37 dB only!

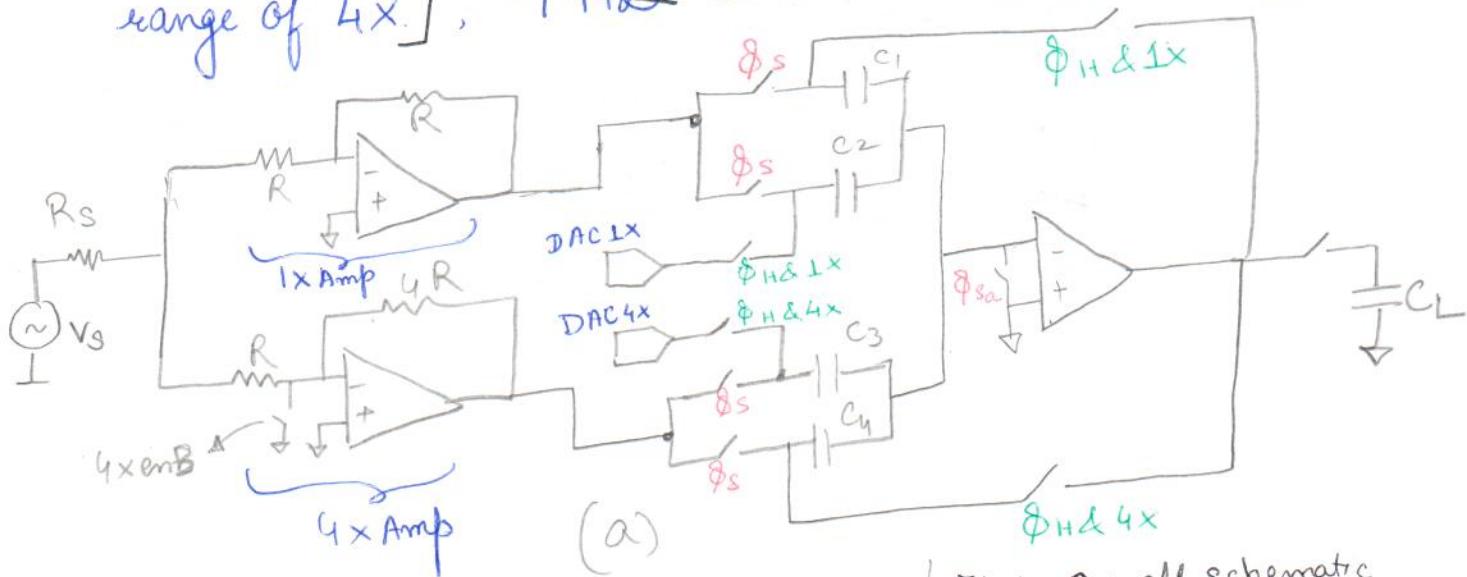
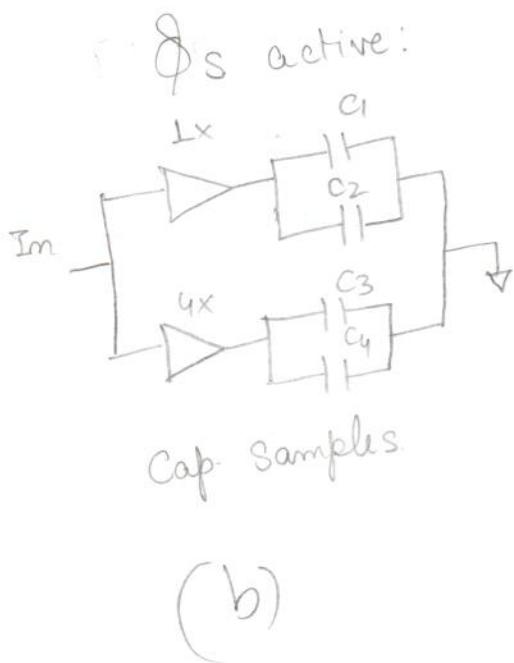
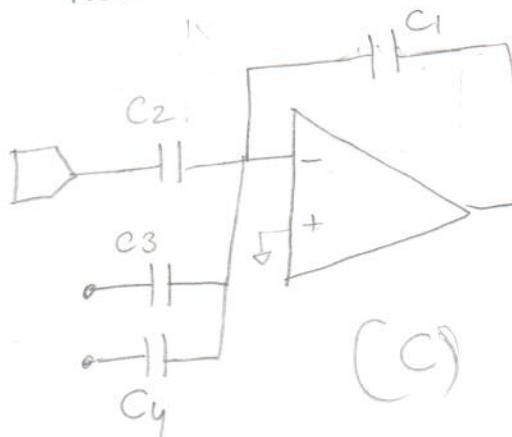


Fig 1: Overall schematic
a) diag. (only single ended (SE) is shown)

- b) & PhiSamp. case
c) PhiH case when 1x decision was made



\$\phi_H\$ active
& 1x branch
needs to be selected



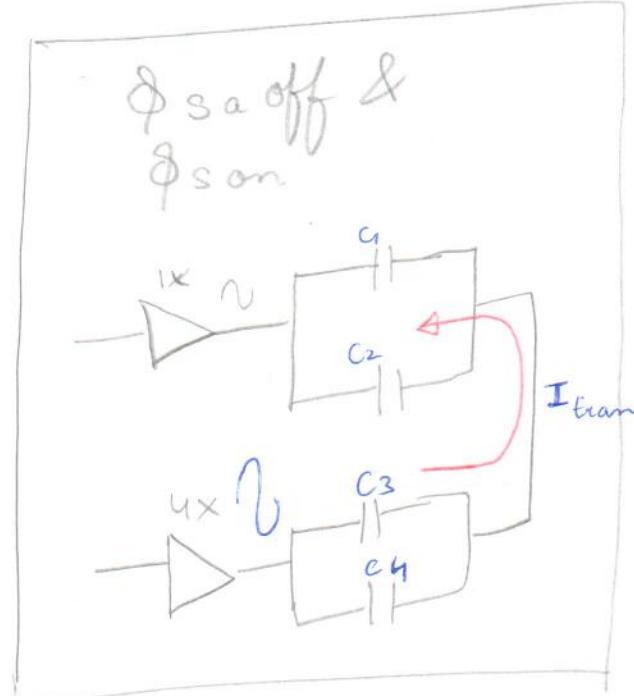
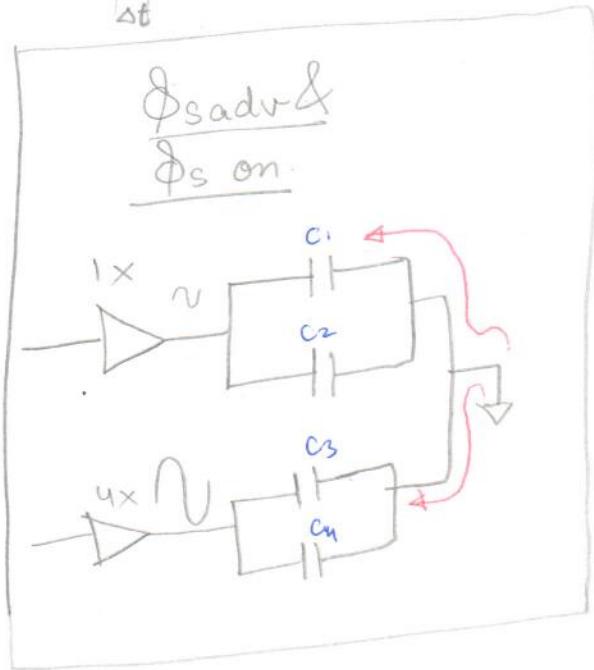
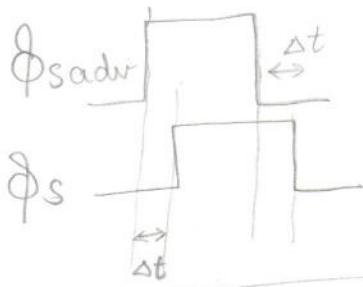
When does the problem occur?

- (a) when input saturates 4x branch & 4x is on
- (b) when 4x is turned off ($4x_{enB} = 1$) just before saturation and turned on for other times (during its linear region)

II) Cause of the problem:

There are 2 causes of the problem:

- 1) Signal the Input voltage change between
phi_{sadv} & phi_s



Say Input = $A \sin \omega t$

→ When $\phi_{Sadv} = 1, \phi_S = 1$.

All C_1, C_2, C_3, C_4 are charged from virtual ground node.

→ When $\phi_{Sadv} = 0, \phi_S = 1$.

4x signal is: $4A \sin \omega t$.

1x signal is: $A \sin \omega t$.

$\therefore I_{tran} \propto 3A \sin \omega t + 3Aw \cos \omega t$ (\propto slope of change)

\therefore Final charge on cap. C_1/C_2 is:

charge $\propto (A \sin \omega t + K \cdot Aw \cos \omega t)$

↳ Proportionality factor, very small.

→ If 4x never saturates, there is almost no non-linearity (verified using ideal components) $SFDR > 100 dB$

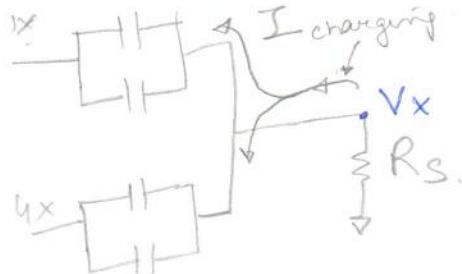
→ If 4x saturates, then 4x output slope is 0.

$\therefore I_{tran} \propto -A \omega_1 \cos \omega_1 t$.

→ Similarly, if sometimes 4x is used (during linear region) and other times turned off, then there will be non-linearity.

Verified: When 4x is always on or turned off before sat, $SFDR < 37 dB$.

2) Virtual ground voltage jump when ϕ_{adv} is turned off, due to finite R_{on} of BPS (Bottom plate sampling) switch



During Sampling,

$$I_{\text{charging}} \propto (A \sin \omega_1 t + g A \sin \omega_1 t) \\ \omega_1 \cos \omega_1 t$$

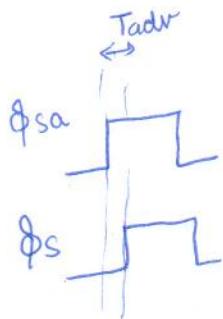
$$\Rightarrow V_x = 0 - I_{\text{charging}} \cdot R_s.$$

Thus depending on slope, my V_x will vary a little, from sample to sample.

Now, if I allow $\propto 4x$ saturation to happen, then V_x is no longer proportional to input, hence the distortion.

III) Verification:

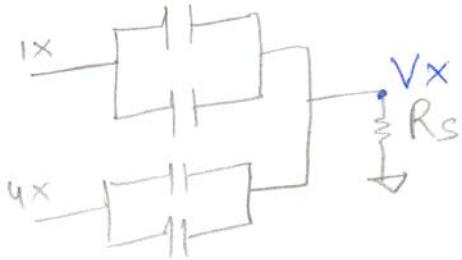
For problem 1, in ideal case scenario,



T _{adv}	Fundamental
500 psec	-2.1 dBV
250 psec	-2.1 dBV
0 psec	-2.1 dBV

3 rd Harmonic	SFDR
-42.3 dBV	40.2 dB
-47.1 dBV	45 dB
-59.7 dBV	57.6 dB

For problem 2 :



Vary R_{switch}

R_{sw} .

10 Ω

0.1 Ω

Fundamental

-2.1 dBV.

-2.1 dBV

3rd Harmonic.

-59.7 dBV

-91.9 dBV

SFDR

57.6 dB

89.8 dB

IV)

Solution :

→ Never choose 1x sample when 4x was on after PT & ϕ_{sadv} clock is off. (1x sample slope provides linear gain, so no THD)

V)

Final comments :

→ Using above solution, when using 1x branch only, obtained > 73 dB SFDR across PT variation & > 65 dB SFDR across PT using 4x branch output.

